Montana Department of Transportation
PO Box 201001
Helena, MT 59620-1001

Memorandum

To: Distribution

From: Mark Goodman PE, Hydraulics Engineer {original signed 8-25-09}

Thru: Paul Ferry PE, Highways Engineer {original signed 8-25-09}

Date: August 25, 2009

Subject: Procedure Memorandum
Culverts in Deep Fills

Many culverts are reaching the end of their design life. In many cases, these culverts have been constructed under high fills. Replacement of these culverts can be very costly as well as cause severe disruption to traffic. These circumstances require that viable alternatives for rehabilitation or special installations be investigated before specifying the traditional remove and replace option.

Attached is a guidance document entitled *Pipe Replacement / Rehabilitation Options for Culverts with Fill Heights Greater than 15 feet*. The purpose of this document is to serve as a checklist for options to consider when replacing pipes in high fills as either a culvert replacement or reconstruct project. The options listed have been successfully used on MDT projects in the past and should be considered viable under the correct conditions.

MAG:djh : Attachment:

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Loren Frazier - Engineering
Mark Goodman – Hydraulics
Paul Ferry – Highways
Damian Krings – Road Design
Tim Conway – Consultant Design
Doug Moeller – Missoula District
Mick Johnson – Great Fall District
Jeff Ebert – Butte District
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Hydraulics Section Staff – (12 copies)

Pipe Replacement / Rehabilitation Options for Culverts With Fill Heights Greater than 15 Feet

Option 1: Keep Existing Pipe in Place:

- Determine remaining service life of the exiting pipe
  - Per the Culvert Service Life Guidelines, if the fill height is greater than 15 feet, the remaining pipe life should be 50 years.
  - In addition to water and soil samples, coupon samples of the existing steel pipe can be taken to determine remaining thickness and remaining pipe life due to corrosion and abrasion.
  - Assume concrete life is 100 years.
  - Evaluate existing performance to ensure there are no existing flooding or erosion problems.
  - Analyze structural capacity of the pipe for current and proposed fill height conditions.
- Considerations for extending the existing pipe
  - Evaluate the condition of the existing pipe with either visual inspection or remote control video.
  - If the pipe is going to be extended more than 50 percent of the in place pipe length, the remaining pipe life should be 50 years.
  - Verify that the extension will align properly with the channel. Channel changes or possibly a vertical or horizontal bend in the pipe may be required.
  - Structural plate pipe can be difficult to attach to and these connection points have caused structural problems in the past.
  - Consult with Geotech on the potential for differential settlement between the existing and new pipe.
  - If the grade is being raised, verify that the class of RCP pipe is adequate.
- Environmental permitting may require retrofitting the existing pipe for fish passage.
- Include channel change, end section(s), environmental requirements, etc. in cost analysis.

Option 2: Install New Pipe(s)

- Consider the condition and age of the existing pipe when determining applicable pipe material options
  - What condition is causing the pipe to be replaced? (i.e. corrosion, abrasion, shape)

- Does the corrosion (soil and water) and metal coupon testing match the condition of the pipe?
- Use modified service life calculation that includes the actual life of the existing culvert to determine service life of the proposed pipe.
- If problems exist, do not specify thinner steel than the existing pipe.

- When specifying steel pipe, consider enlarging the replacement pipe 18 to 24 inches in diameter to allow for future slip lining.
- The material selection should not be based on initial cost only.
  - Consider materials that provide the longest service life.
- Consider detour, excavation, large pipe removal, edge protections, and bedding costs in the cost estimate.
- Backfill could be imported if necessary to extend the service life.
  - Evaluate cost and availability of backfill.
  - Bid alternates with concrete pipe if importing more that 1000 cy of backfill for steel pipe.
- Bid alternates with reinforced concrete box if the steel option is greater than 10 feet in diameter.
- Limit pipe options to concrete and appropriately sized (thickness) coated steel.
- Steel is a valid option provided:
  - The full service life of 75 years is met based on the modified service life calculation that includes the actual life of the existing culvert to determine the service life for the proposed pipe.

Option 3: Insert New Pipe into Existing pipe

- Verify hydraulic capacity of lined culvert.
  - If the level of service cannot be met without overtopping the roadway, lining is not a valid option.
  - Evaluate the risk of upstream flooding.
  - Evaluate the inlet and outlet edge and channel protection for increased velocity and higher water surface elevations.
- The host pipe may have to be cleaned which, can be difficult enough to be cost prohibitive.
- Obtain a detailed survey of the profile and interior geometry of the pipe to determine if the recommended size pipe can be inserted. In many cases, the liner pipe will be 24 inches smaller.
- Allow adequate space for grouting. Base the decision on minimum survey dimensions versus the reported pipe diameter.

- Determine if there are any site constraints that will inhibit the contractor from accessing the sites.
  - Require a staging area to set up and insert the liner.
  - Identify areas that will require extra ROW, railroad involvement, or construction permits.
  - Identify which end the liner pipe will be inserted from, ie. inlet or outlet (typically the outlet is preferred).
  - Proximity to the railroad property could affect insert capability.
- Determine service life of lining pipe material.
  - Specify coating as required.
  - Assume grout in the annular space will mitigate soil side corrosion.
  - Reconsider steel lining if the service life cannot be obtained based on the water samples.
- Plastic options up to 36 inches include:
  - HDPE solid wall pipe with welded or snap tight joints.
  - Corrugated PVC liner pipe.

Option 4: Jack & Bore New Pipes

- Determine if there are any site constraints that will affect the jacking & boring contractor from accessing the sites.
  - Require a 12-ft x 36-ft boring pit to set up and operate boring equipment
  - Maintain a minimum distance of 20-ft from edge of pavement of the PTW
  - Maximum boring slope of 0.2 ft/ft (20%)
  - Must be a min. of 5-ft between new pipe and old pipe (meas. outside edge to outside edge)
  - Identify areas that will required extra ROW, railroad involvement, or construction permits.
  - Identify which end to be jacked and bored from, ie. inlet or outlet (typically the outlet is preferred)
- Existing pipes will be plugged and abandoned.
- Check for conflicts with utilities or irrigation systems.
- As much information as possible should be obtained about the existing fill material where pipes will jacked & bored. Bedrock, groundwater, rocks in the fill, and the ground / fill interface can be a significant problem.
- Currently, MDT has had good experience with specifying 3/8 to 1/2 inch smooth steel pipe up to 48 inches in diameter. The use of other pipe materials and larger diameters up to 60 inches will be investigated in the future.

- As the jack and bore length increases, the accuracy, risk, and cost of this method will also increase which may preclude it as a viable option. Evaluate costs with other alternatives.

Option 5: Cured in Place Pipe (CIPP)

- If the pipe is severely corroded or significantly deformed, this method should not be considered.
- The pipe will have to be cleaned thoroughly, which can be costly.
- For pipes greater than 36 inch, a water source will have to be identified. If a water source is not available, the water will have to be trucked in, which will significantly increase the cost.
- The discharge of heated water can environmentally damage downstream waters. Discharge water may have to be trucked offsite to a predetermined disposal area.
- Check costs closely. Contact suppliers with site data and photos to obtain a unit cost estimate.
- Determine if there are any site constraints that will affect the contractor from accessing the sites.
  - Require a staging area to set up and insert the liner.
  - Identify areas that will required extra ROW or Construction Permits.

Option 5: Invert Paving

- If all of the pipe except the invert is in good condition, the invert can be paved with concrete.
- Fill voids and hollow areas beneath the pipe with grout.
- Extend concrete the sufficiently up the sides and utilize wire mesh for concrete reinforcement.
- Analyze culvert hydraulics and improve cut off walls and edge protection as necessary to account for increased velocities.
- Boulders or baffles may be necessary to retrofit the culvert for fish passage.

Comparison of Alternatives

Option	Cost	Size Range	Advantages	Limitations
Option 1: Keep Existing Pipe in Place	Low	-	Low construction cost Detour not required Minimal permitting required	Difficult to estimate remaining life May not meet current hydraulic standards Extensions may require channel changes
Option 2: Install New Pipe	High	-	Full service life is restored Meets current hydraulic and environmental standards	High cost Detour or road closure required
Option 3: Insert New Pipe into Existing	Med	120” or Less	Full service life is restored Detour not required Applies to a large range of diameters	Need a large staging area Reduces capacity of culvert May increase velocities Host pipe shape must be uniform
Option 4: Jack and Bore New Pipe	Med / High	60” or Less	Full service life is restored Detour not required Avoids excavation of large fills	Need a large staging area Limited to smaller diameters Uniform embankment fill required – no large rocks.
Option 5: Line Existing Pipe with CIPP	Med / High	60” or Less	Detour not required No grouting required Smooth interior	Specialized equipment and personnel required Water source required Discharge of water may be an environmental problem
Option 6: Invert Paving	Low	60” or Greater	Work limited to bottom 1/3 of pipe Can be retrofitted for fish	Applies to culverts with invert damage only May increase velocities

Comparison of Alternatives